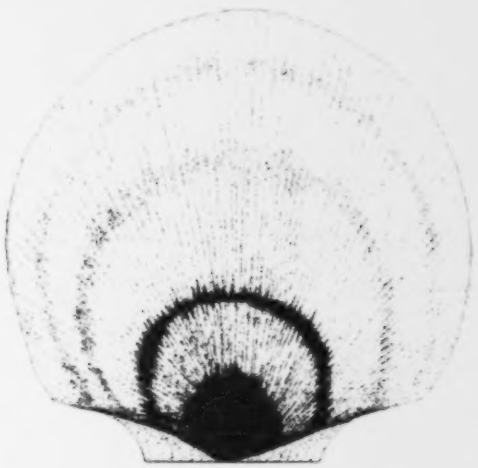
Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Maritimes Region
Canadian Science Advisory Secretariat
Science Advisory Report 2007/013

STOCK ASSESSMENT REPORT ON SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN SCALLOP PRODUCTION AREAS 1 TO 6 IN THE BAY OF FUNDY



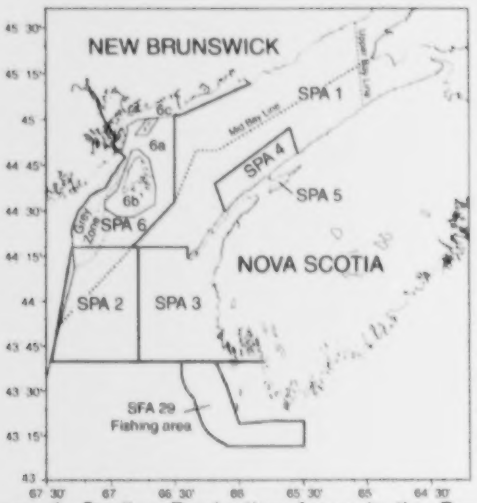


Figure 1. Scallop Production Areas in the Bay of Fundy. Refer to full detail map in Figure 47 (last page) for place names.

Context

The sea scallop Placopecten magellanicus occurs only in the northwest Atlantic from Virginia north to Labrador. Within this area, scallops are concentrated in persistent, geographically discrete aggregates or "beds", many of which support valuable commercial fisheries. The larger beds are found offshore and in the Bay of Fundy. Scallops in different beds, and in different areas of large beds, show different growth rates and meat yields.

Unlike many commercial scallop species, the sea scallop has separate sexes. Male scallops develop a white gonad in the summer months, while female gonads are bright red. Eggs and sperm are released into the water and fertilization takes place in the sea. Spawning begins in late August to early September, and the larvae drift in the water for almost a month before settling to the bottom in October.

The Bay of Fundy area is fished by the Full Bay and the Mid-Bay licensed fleets. Full Bay vessels are 45' to 65' and Mid-Bay vessels are generally between 30' to 45'. Full Bay licensed vessels are permitted to fish all the Bay of Fundy. The Mid-Bay license holders have access to the New Brunswick side and portions of the Nova Scotia side of the Bay of Fundy to the Mid-bay line and a portion of Scallop Production Area (SPA) 2. There are also 16 Upper Bay Licences restricted to the upper reaches of the bay. The fishery has been managed using limited entry, gear size limits, seasonal closures, minimum shell height, meat count and individual meat weight restrictions. The gear width limit is 5.5 m with ring size of not less than 82 mm inside diameter. Quotas were introduced in 1997. Total allowable catches (TACs) are set and landings are reported in terms of meat weights (adductor muscles).

May 2007

Canada

SUMMARY

All of Bay of Fundy

- This is the second year that the *F/V Royal Fundy* was used to conduct the surveys in SPAs 1 to 6 after the unexpected retirement of the standard survey vessel the *CCGV J.L. Hart* in 2004. There is no compelling reason to believe that there is a significant difference in the survey series due to the change of vessels.
- Survey coverage was increased in 2006 over previous years (875 tows vs. 646 in 2005 and an average of 524 tows in 2000 to 2004) and helped reduce the uncertainties identified last year for assessments in SPA 1B and 6.
- Objectives and associated reference points are being developed for these fisheries. Discussions between DFO and the fishing industry to develop reference points for the scallop fisheries in the Bay of Fundy need to be continued.
- In order to maximize yield-per-recruit, the impact of fishing practices on the mortality of recruit and prerecruit scallops needs to be investigated.
- Research and monitoring to establish the relationship between scallop biomass and future recruitment is required.
- Research and monitoring to determine the conditions leading to episodic die-offs is required.

SPA 1A

- Landings were 160 t against a TAC of 100 t for the 2005/2006 season.
- Commercial catch rates have been declining from a recent peak in 2002.
- Survey estimates indicate that the larger than average 1998 year-class has been fished down with no strong upcoming year-classes evident in the 2006 survey size frequencies.
- A fishing strategy of 75 t in SPA 1A for 2006/2007 and 2007/2008 has approximately a 0.30 probability of exceeding exploitation rate of 0.2 which could allow the population biomass to increase slightly.

SPA 1B

- Landings were 144 t against a TAC of 225 t for the Full Bay Fleet in the 2005/2006 season, and 185 t against a TAC of 225 t for the Mid and Upper Bay fleets in the 2006 season.
- Commercial catch rate has declined for all fleets during the last three years but it is still above the low that was observed in 1997.
- There were signs of two significant year-classes in the 2006 survey that will recruit to the fishery in 2007 and 2008.
- In the 2006 survey, there was no substantial change in abundance of commercial size scallops from 2005 but meat yield was the lowest of the last three years in the main areas of abundance.
- If meat yields persist at low levels during 2006/2007, fishing mortality will be higher than expected for any TAC established. Meat yield sampling will be required to evaluate this concern.
- If meat yields in 2006/2007 increase to levels observed during 1997-2005, then there would be no reason to change the advice provided in 2005/2006 (400 t).

SPA 2

- This area is considered to be marginal habitat for scallops and is not monitored regularly.
- A 2006 survey found minimal catch with a high percentage of clappers. There was little to no sign of recruitment suggesting that this area will not support a fishery in the near future.

SPA 3

- Landings in 2005/2006 were 187 t against a TAC of 200 t. An interim TAC of 50 t was granted for October/November of the 2006/2007 season and the most recent record of landings against the TAC was 11 t.
- Commercial catch rate has declined in this area since the high of 2003 and the 2006 estimate of 13 kg/h falls below the long-term median (14.5 kg/h).
- The survey biomass index indicates an increase in 2006 as the population is mainly made up of older scallops.
- There appears to be little sign of recruitment for 2007.
- Based upon a surplus production model, a catch of 200 t in 2006/2007 would likely result in little change in biomass.

SPA 4

- Landings in 2005/2006 were 133 t against a TAC of 150 t. An interim TAC of 100 t was set for the 2006/2007 season which opened 1 October 2006.
- Commercial catch rates in 2005/2006 (11.4 kg/h) declined from the previous four years and were below the median for the time-series (21.3 kg/h). Average catch rates from October 2006 (9.9 kg/h) are 18% lower than the average for the same time in 2005 (12.2 kg/h).
- Survey numbers indicate that the stronger than average 1998 year-class has been fished down and there are no indications of any substantial recruitment for the next two to three years.
- A catch of between 100 and 125 t in each of 2006/2007 and 2007/2008 would result in exploitation rates with a 50% or lower probability of exceeding 0.2.

SPA 5

- Landings in 2006 were 6.1 t against a TAC of 15 t.
- Commercial catch rate in 2006 (12.5 kg/h) was lower than the long term median (21 kg/h) and approximately half of the catch rate reported in 2005.
- The mean number per tow of commercial size scallops declined by 31% from 2005 to 2006. The commercial portion of the population is below the 1997-2005 median and little recruitment is expected for the next two years.
- The TAC for 2007 should not exceed the average over the low abundance periods (1997-1999) of 10 t.

SPA 6

- Landings to 10 November 2006 were 91 t against a TAC of 100 t.
- The Mid-Bay catch rate may be a better reflection of population trends as it is based on somewhat higher levels of effort but this index does not indicate any large changes in the last 10 years. The commercial catch rate for the Full Bay Fleet increased from 2000 to 2004 but given the low levels of effort, this index may not be tracking changes in the population.

- The abundance of commercial size scallops appears to remain unchanged from 2005 in SPAs 6A and 6C and has possibly declined as much as 44-46% in SPA 6B. Above average recruitment was only detected in SPA 6A.
- There is no evidence to advise increasing the TAC for 2007 above the current catches of 82-91 t.

BACKGROUND

A meeting of the Regional Advisory Process was held 12-13 December 2006 at the Future Inns, in Dartmouth, N.S., to review the 2006 scallop fishery and assess the status of the scallop stocks in Scallop Production Areas 1 to 6 in the Bay of Fundy as well as to provide the scientific advice for the 2007 fishery. Specifically, the meeting addressed:

The assessment of the status of the scallop stocks, including:

- An analysis of all available commercial and survey information.
- For SPA 1 (8 to 16 mile Digby Area) and SPA 4, application of the assessment model described in Smith et al. (2003).
- For SPA 1 (8 to 16 mile Digby Area) and SPA 4, review of interim advice provided for 2006/2007 and recommendations for 2007/2008.
- For the rest of SPA 1, SPA 3, SPA 5 and SPA 6, the provision of advice for 2007.
- For all areas, estimate by-catch of non-scallop species in the fishery for as many years as possible. However, as there is no observer coverage of the scallop fleets in SPAs 1 to 6, there was no means to estimate bycatch of non-scallop species.

Impact of a change in survey vessel:

- This is the second year that the *F/V Royal Fundy* was used to conduct the surveys in SPAs 1 to 6 after the unexpected retirement of the standard survey vessel the *CCGV J.L. Hart* in 2004. There was no opportunity to conduct comparative surveys between the *CCGC J.L. Hart* and the *F/V Royal Fundy*. The standard survey 4-gang Digby drags are used on the *F/V Royal Fundy* and all survey protocols followed on the *CCGC J.L. Hart* remain the same. Analysis of data from 2005 and 2006 suggest that the indices from the *F/V Royal Fundy* surveys are comparable to those from the *CCGV J.L. Hart* surveys. There is no compelling reason to believe that there is a significant difference in the survey series due to the change of vessels.

Increased survey coverage:

- Survey coverage was increased in 2006 over previous years (875 tows vs. 646 in 2005 and an average of 524 tows in 2000 to 2004) and helped reduce the uncertainties identified last year for assessments in SPA 1B and 6. In particular, SPA 6 received a total of 180 survey stations over the three subareas compared to 45 stations in 2005 and no survey in 2004. A pilot survey looking at combining repeated stations from 2005 plus random stations in 2006 was also included in the 2006 survey of SPA 6. Stations were also added in SPAs 1A and 1B. The last survey of SPA 2 was in 1996 when 11 surveys stations were covered in this area. In 2006, 51 stations on Northeast and Southwest Banks were added to the survey to provide an update on the scallop distribution there.

Changes in meat yield:

- Trends in the survey data and reports from industry suggest that there have been recent changes in meat yield. Declines in meat weight-at-shell height were particularly evident in the Cape Spencer and the 8 to 16 mile (Digby) survey areas. Meanwhile, meat weights showed increases in the 2 to 8 mile (Digby) survey area corresponding to SPA 4, the 2 to 8 mile Youngs Cove and Hampton strata (SPA 1A), Lurcher (SPA 3), and SPA 6B. In all areas, average meat weights were below the 2001 estimates which were the highest or among the highest in most areas.

ASSESSMENT

SPA 1 – Inner/Upper Bay of Fundy

SPA 1 covers most of the mid to inner Bay of Fundy. Since 2002, it has been managed as two separate areas: SPA 1A and SPA 1B (refer to detailed map on last page, Figure 47). SPA 1 is fished to varying levels by all three fleets. The Full Bay Fleet can fish throughout all of SPAs 1A and 1B. However, the other fleets are restricted to SPA 1B, the Mid Bay Fleet fishing only north of the Mid Bay line, and the Upper Bay Fleet fishing only east of the Upper Bay line.

SPA 1A – Southwest Bay of Fundy

Fishery

The 2005/2006 quota for the Full Bay Fleet in SPA 1A was 100 t. This was down from 1200 t in 2002/2003 and below the long term average (1997-2006). Landings to 4 December 2006 were 160 t for the Full Bay Fleet during the 2005/2006 fishing year.

Landings (meats, t) Full Bay

Year	Avg. 97-01	2001/ 2002[1]	2002/ 2003[2]	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007[3]
TAC (t)	240	700	A: 1200	A: 700	A: 400	A: 100	A: 100
Landings (t)	210	745	A: 913	A: 464	A: 322	A: 160	A: 22

[1] Starting 1 October 2001, the Full Bay Fleet fishing season changed from a calendar year to 1 October to 30 September.
[2] Full Bay TAC was split into SPA 1A and SPA 1B in 2002/03. Quotas and landings for 1997-2001/2002 are for all SPA 1; those for 2002/2003 to 2006/2007 are for SPA 1A only.
[3] Interim TAC, landings to 4 December 2006.

Since 1976, landings in SPA 1A have shown two large peaks; one in 1989 and a more recent one in 2003 with landings currently declining (Figure 2). The 1989 peak was seen throughout the Bay while the recent one was confined to SPA 1A.

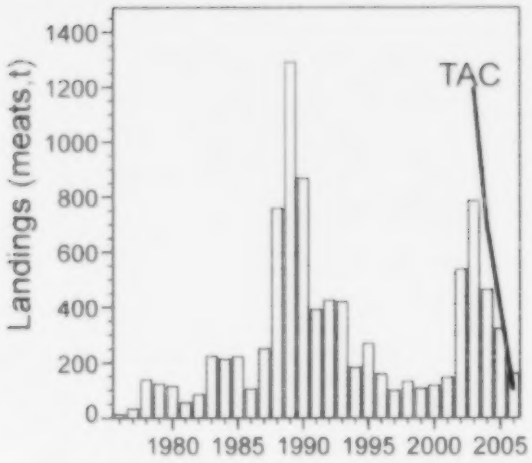


Figure 2. Scallop landings (meats, t) in SPA 1A.

Resource Assessment

Commercial catch rate in SPA 1A declined from a high in the late 1980's to a low in 1997. With the large 1998 year-class recruiting to SPA 1A, it peaked again in 2002, and is now declining (Figure 3**Error! Reference source not found.**).

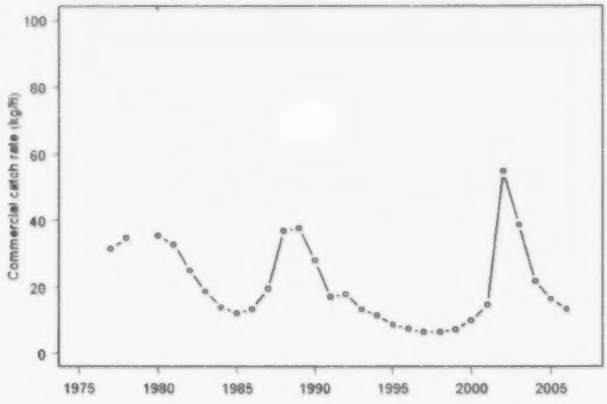


Figure 3. Commercial catch rate (kg/h) for scallops in SPA 1A.

In SPA 1A, resource surveys have been conducted annually since 1981 in the 8 to 16 mile area off Nova Scotia. Up to 2003, the surveys were conducted in May-June, but the expanding distribution of lobster traps in the area necessitated rescheduling the survey to August-September.

Having declined from a recent peak in 2002, the survey abundance index for commercial size (≥ 80 mm shell height) scallops in the 8 to 16 mile area during 2006 was similar to that of 2005 (Figure 4). Size frequency distributions from the 2000-2006 surveys show the 1998 year-class as it recruited to the fishery and was fished down (Figure 5). This year-class has supported the fishery in SPA 1A since it started to recruit in late 2001. It has been fished heavily and the abundance of commercial size scallops has now declined to the low levels observed in 1994-

2000 (Figure 4). No strong upcoming year-classes were evident in the 2006 survey size frequencies (Figure 5).

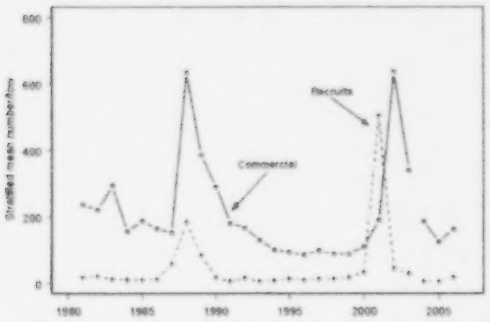


Figure 4. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height) and recruit (65-79 mm shell height scallops in the 8 to 16 mile area of SPA 1A. The break in the survey series indicates the change in timing of the survey from June in 1981-2003 to August/September in 2004-2006.

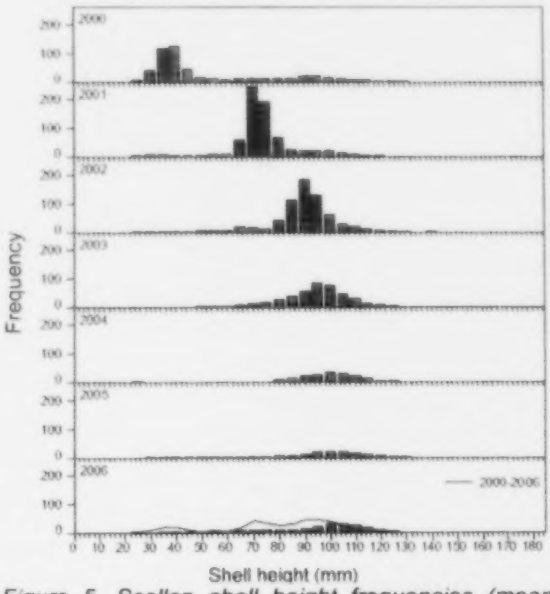


Figure 5. Scallop shell height frequencies (mean no./tow) from surveys of the 8 to 16 mile area of SPA 1A. Surveys were conducted in June during 1981-2003 and in August/September during 2004-2006.

The population model described in Smith et al. (2003) was revised in 2004 to improve its ability to forecast population size for the following year. Differences between predicted and estimated biomass in 2002 (Figure 6) partly reflect the increase in growth rate noted in 2001, as a constant growth function was assumed for this model. The other reason for the difference between the two sets of estimates for this time period may be due to imperfect corrections for the changing relative behaviour of the lined and unlined survey gear when densities are high. Further analysis of the relative selectivity of the survey gear will have to be conducted to solve this issue. The predicted mean biomass for the start of the 2007/2008 season was based on a catch of 100 t for 2006/2007.

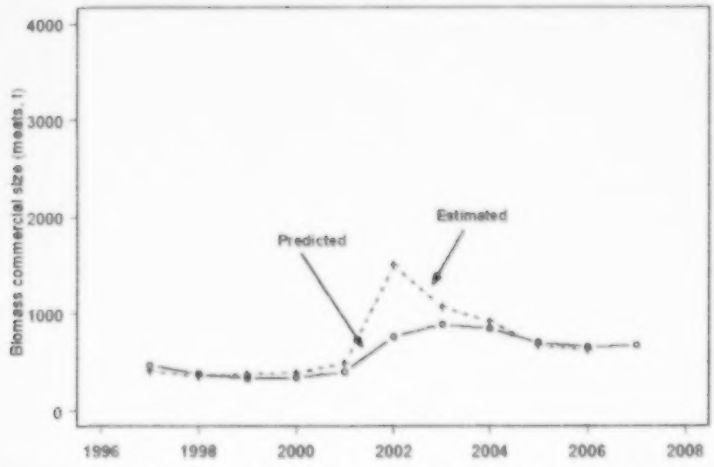


Figure 6. Comparison of predicted biomass from the previous year with the estimated biomass of commercial size (≥ 80 mm shell height) scallops in the current year for the 8 to 16 mile area of SPA 1A.

Conclusions and Advice

In a previous assessment, exploitation rate (e) was suggested as a fishery indicator with an upper limit reference point of 0.2 based on empirical evidence from earlier work (DFO 2004). A catch of 75 t in 2006/2007 is expected to result in an exploitation rate of 0.15. With all of the uncertainties contained in the model, a catch of 75 t has a probability of 0.29 of exceeding 0.2. For 2007/2008, a catch of 75 t would result in an exploitation rate of 0.14 with about a 0.31 chance of exceeding 0.2. A fishing strategy of 75 t for this season and next season would result in a modest increase in population biomass. All catches below these levels should result in small increases in population biomass.

		Catches in 2007/2008				
Catch in	Pr(e≥0.2)	Pr(e≥0.2) (exploitation)				
2006/07	(exploitation)	50 t	75 t	100 t	125 t	150 t
75 t	0.29 (0.15)	0.13 (0.09)	0.31 (0.14)	0.47 (0.19)	0.59 (0.24)	0.68 (0.24)
100 t	0.51 (0.21)	0.17 (0.10)	0.35 (0.15)	0.50 (0.20)	0.62 (0.25)	0.70 (0.30)
150 t	0.75 (0.30)	0.24 (0.11)	0.43 (0.17)	0.56 (0.23)	0.66 (0.28)	0.73 (0.39)

There are no signs of above average recruitment for the next few years, so fishing above this level will likely decrease biomass.

SPA 1B – Northern/Upper Bay of Fundy

Fishery

Quotas were not reached in SPA 1B in 2005/2006 (Figure 7). Landings were 144 t for the Full Bay Fleet (2005/2006 fishing year), 136 t for the Mid Bay Fleet (2006 fishing year), and 49 t for the Upper Bay Fleet (2006 fishing year).

Landings (meats, t) Full Bay

Year	Avg 97-01	2001/ 2002[1]	2002/ 2003[2]	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007[3]
TAC (t)	240	700	B: 100	B: 200	B: 200	B: 225	B: 50
Landings	210	745	B: 33	B: 210	B: 228	B: 144	B: 7

[1] Starting 1 October 2001, the Full Bay Fleet fishing season changed from a calendar year to 1 October to 30 September.

[2] Full Bay TAC was split into SPA 1A and SPA 1B in 2002/03. Quotas and landings for 1997-2001/2002 are for all SPA 1; those for 2002/2003 to 2006/2007 are for SPA 1B only.

[3] Interim TAC, landings to 4 December 2006

Landings (meats, t) Mid and Upper Bay

Year	Avg. 97-01	2002	2003	2004	2005	2006
TAC (t)	66	100	150	150	200	225
Landings	66	186	212	261[1]	206	185

[1] Remaining quotas in SPAs 1 and 6 combined 2 August 2004 with most of the combined quota coming from SPA 1.

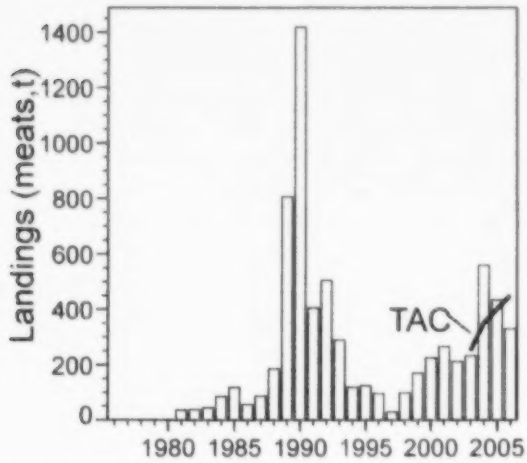


Figure 7. Scallop landings (meats, t) in SPA 1B (for all fleets).

Resource Assessment

Commercial catch rate has declined for all fleets during the last three years but it is still above the low that was observed in 1997 (Figure 8).

In SPA 1B, resource surveys have not covered the whole area consistently. Surveys off of Digby were expanded to the Cape Spencer grounds in 1996, and the Upper Bay area was added after 2000. The part of SPA 1B that is within SFA 28B and outside of Cape Spencer (Mid Bay North area) has been covered as time permitted. Due to research vessel problems, the 2004 survey only covered the Cape Spencer grounds. The 2005 and 2006 surveys, using a commercial vessel, had more extensive coverage in SPA 1B than in previous years.

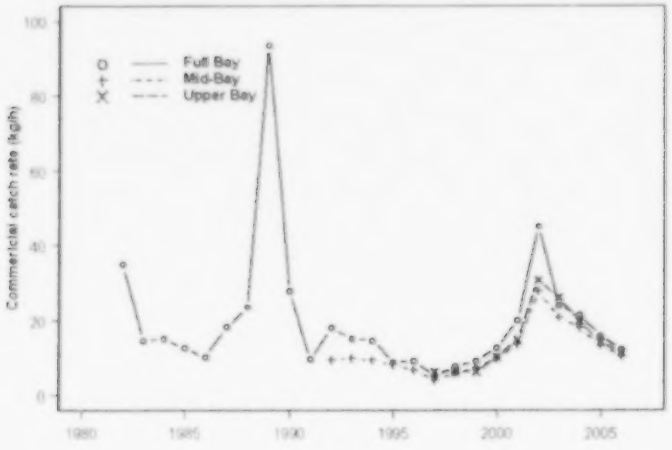


Figure 8. Commercial catch rate (kg/h) for scallops in SPA 1B.

In the Cape Spencer area, there were fewer commercial size scallops observed in 2006 relative to some recent years but 2006 was still greater than the median during 1997-2006 (136 scallops/tow; Figure 9). Recruitment in this area has remained relatively constant, with little sign of the 1998 year-class observed in the 8-16 mile area of SPA 1A. In 2006, survey shell height frequencies showed a mode of scallops at approximately 70 mm (Figure 10) which were located in a band along the New Brunswick side of the Mid Bay Line and represented the highest level of recruits observed annually in the 1997-2006 Cape Spencer time series.

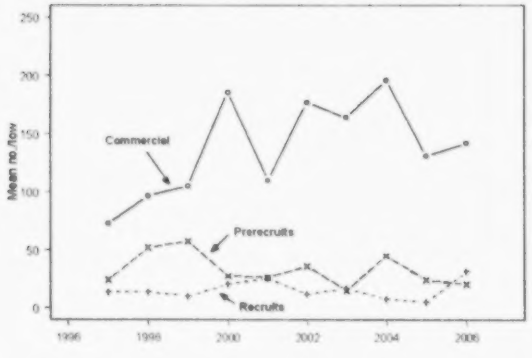


Figure 9. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height), recruit (65-79 mm shell height), and prerecruit (< 65 mm shell height) scallops in the Cape Spencer area of SPA 1B.

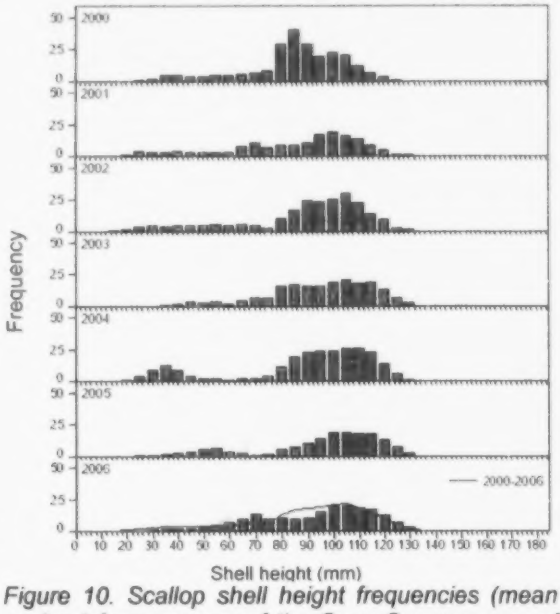


Figure 10. Scallop shell height frequencies (mean no./tow) from surveys of the Cape Spencer area of SPA 1B.

In the remaining part of SPA 1B that is within SFA 28B (Mid Bay North area), a range of 6 to 69 survey tows have been conducted annually since 1997. The limited survey data in this area

suggest that, with the exception of a strong peak in 2002, the number of commercial size scallops has been similar over time (Figure 11). The abundance of recruits (65-79 mm shell height) and prerecruits (< 65 mm shell height) also showed relatively low variability over time although both occurred at their highest levels during 2006. Shell height frequencies indicate that there are two modes below commercial size, one at 55 mm and another at 75 mm (Figure 12). These recruits and prerecruits appear to be distributed west of the Upper Bay Line (Figures 13, 14, and 47).

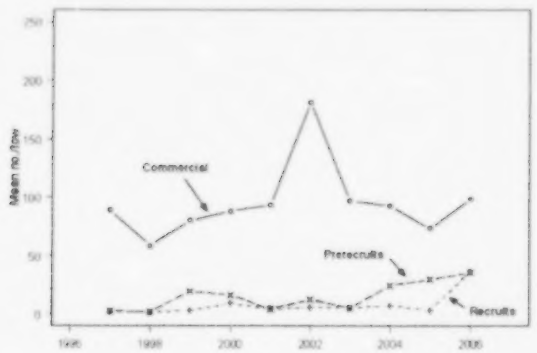


Figure 11. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height), recruit (65-79 mm shell height), and prerecruit (< 65 mm shell height) scallops in the Mid Bay North area of SPA 1B.

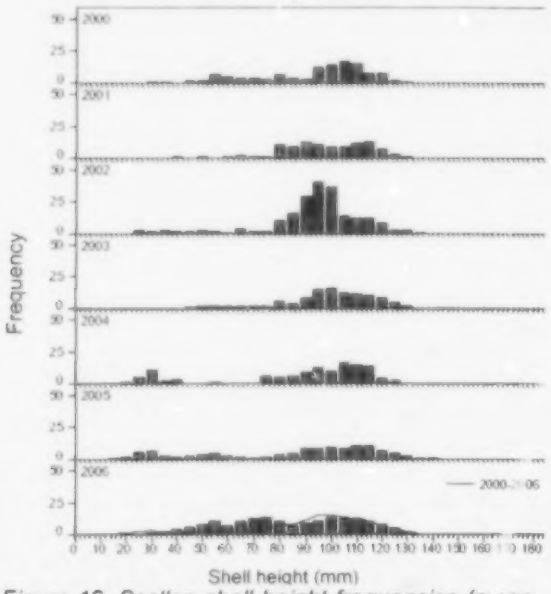


Figure 12. Scallop shell height frequencies (mean no./tow) from surveys of the Mid Bay North area of SPA 1B.

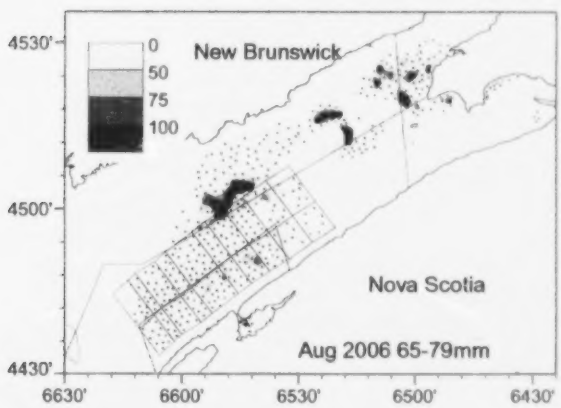


Figure 13. Spatial distribution of scallop catches from the 2006 survey of SPAs 1 and 4 for recruit size (65-79 mm shell height) scallops. Positions of tow locations are indicated.

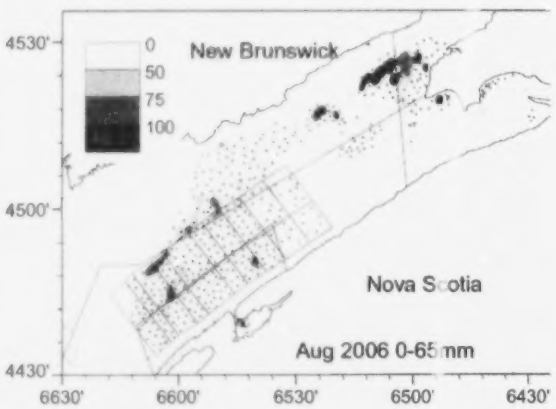


Figure 14. Spatial distribution of scallop catches from the 2006 survey of SPAs 1 and 4 for prerecruit size (< 65 mm shell height) scallops. Positions of tow locations are indicated.

DFO surveys have been conducted in the Upper Bay area since 2001. The abundance of commercial size scallops in 2006 appeared to be similar to that in 2005 but considerably lower

than levels observed during 2001-2003 (Figure 15). Meanwhile, abundance of recruits and prerecruits in 2006 was well above the 2001-2006 median (recruits: 17 scallops/tow; prerecruits: 15 scallops/tow). Shell height frequency data show that the increase in prerecruits is primarily due to a relatively large mode of scallops at about 55 mm (Figure 16).

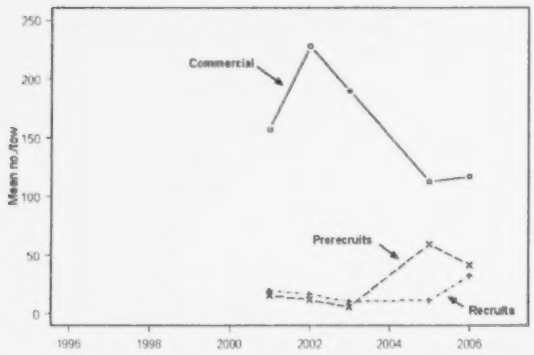


Figure 15. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height), recruit (65-79 mm shell height), and prerecruit (< 65 mm shell height) scallops in the Upper Bay area of SPA 1B.

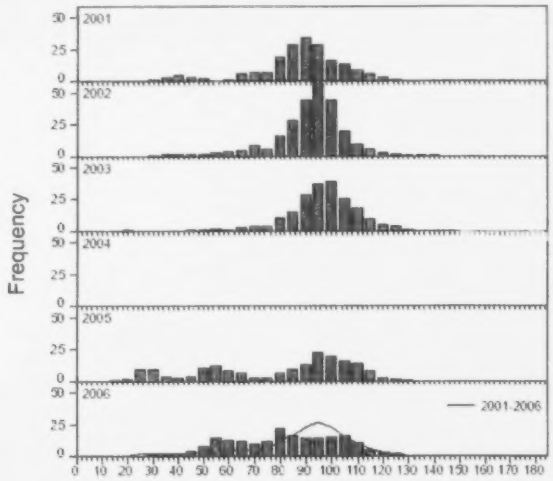


Figure 16. Scallop shell height frequencies (mean no./tow) from surveys of the Upper Bay area of SPA 1B.

Conclusions and Advice

During 2005-2006, only 73% of the quota for all fleets in SPA 1B was landed. Industry indicated that meat yields were low over the summer and it was uneconomical to continue fishing. Commercial catch rates have also declined during the last three years and are now approaching the low levels that were observed in 1997. There were signs of two significant year-classes in the 2006 survey that will recruit to the fishery in 2007 and 2008. In the 2006 survey, there was no substantial change in abundance of commercial size scallops from 2005 (numbers/tow similar or slightly higher than 2005) but meat yield was the lowest of the last three years in the main areas of abundance.

The causes and consequences of variability in meat yield are not well understood. If meat yields persist at low levels during 2006/2007, fishing mortality will be higher than expected for any TAC established. Given the increased abundance of recruits and prerecruits relative to commercial size scallops observed in the 2006 survey and the ability to blend the catch to achieve meat counts, this may also result in increased mortality of smaller size classes and reduced yield-per-recruit although such analyses have yet to be undertaken. Meat yield sampling will be required to evaluate this concern. If meat yields in 2006/2007 increase to levels observed during 1997-2005, then there would be no reason to change the advice provided in 2005/2006 (400 t). Fishing may be concentrated in the winter season of 2006/2007 because yields were reported to be better last year during the winter. The largest part of the fishery in the Bay of Fundy will be based in SPA 1B for the next two years.

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition, research and monitoring focussing on determining the conditions resulting in episodic die-offs is required.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruit and prerecruit scallops needs to be investigated.

Delayed reporting (logbooks) by the Mid and Upper Bay fleets, although improving, continues to be a problem.

SPA 2 – Southwest and Northeast Bank

SPA 2 consists of marginal habitat for scallops and as a result is not monitored regularly with the rest of the Bay of Fundy and approaches. A survey consisting of 51 tows in this area during 2006 found minimal catch with a high percentage of clappers (Figure 17). There was little to no sign of recruitment suggesting that this area will not support a fishery in the near future.

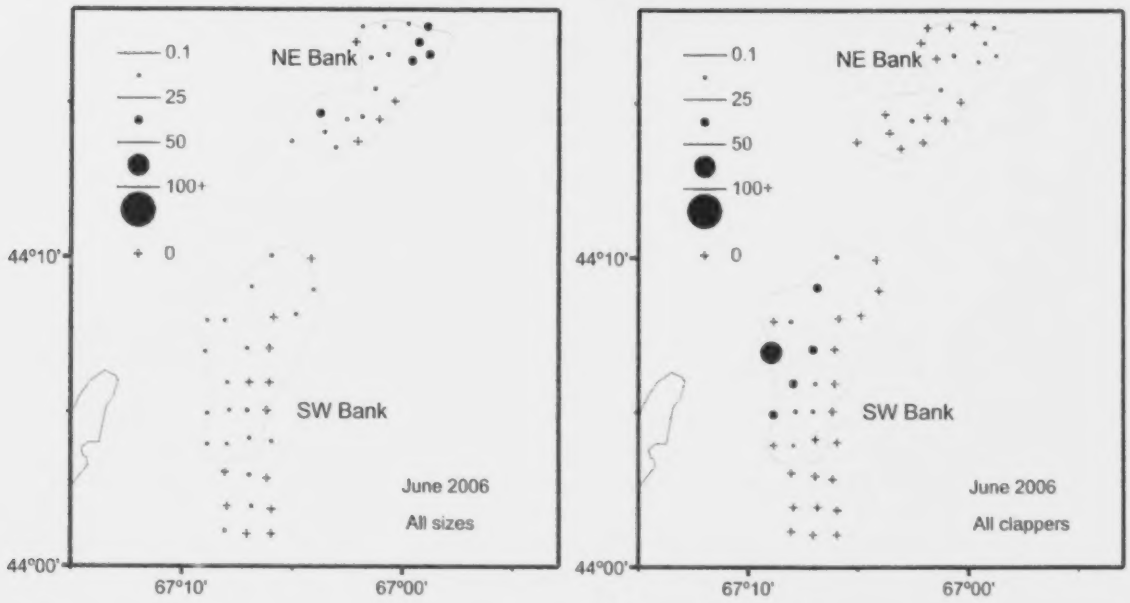


Figure 17. Spatial distribution of scallop catches from the June 2006 survey of SPA 2. Left panel: catches of all sizes of live scallops; right panel: catches of all sizes of clappers (paired empty shells). Positions of tow locations are indicated on the map.

SPA 3 – Brier Island, Lurcher Shoal, and St. Mary's Bay

Fishery

Although scallops can be found throughout most of this area, there are three main beds, those around Lurcher Shoal, below Brier Island, and in St. Mary's Bay. St. Mary's Bay (formerly SPA 7) was combined with SPA 3 in 1999 for management purposes with a single TAC. The lobster fishery influences the scallop-fishing season throughout this area.

Landings in SPA 3 increased each year from 1991 to 1994, reaching a high of 1439 t (Figure 18). Landings declined from 1995 until 1998. However, there is uncertainty about the landings from 1991 to 1996, due to misreporting.

The landings for SPAs 3 and 7 have been combined since 1999. There were serious doubts raised about whether all of the landings reported in 1999 for SPA 3 came from this area. There does not appear to be any reason to suspect that landings reported to SPA 3 in subsequent years were from other areas. In 2001-2004, effort had been redirected from SPA 3 to other areas.

Landings for the 2005/2006 fishing year were 187 t against a TAC of 200 t. An interim TAC of 50 t was granted for October/November of the 2006/2007 fishing season and the most recent record of landings against the TAC was 11 t.

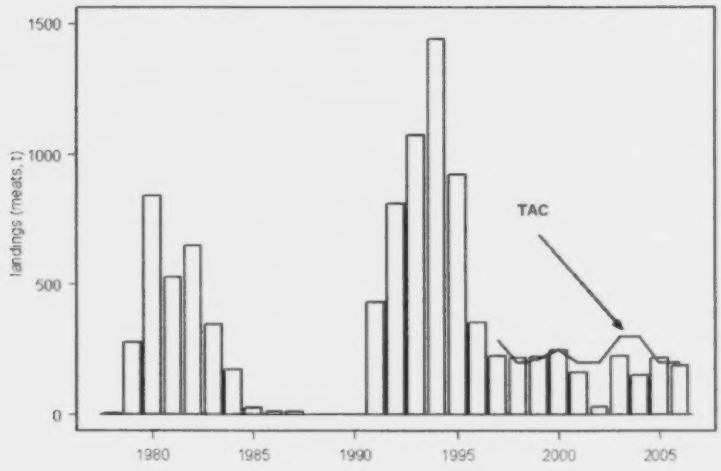


Figure 18. Scallop landings (meats, t) in SPA 3.

Landings (meats, t)

Year	Avg. 1997-00	2001	2002	2003	2004	2005	2005/ 2006	2006/ 2007[1]
TAC	238	200	200	300	300	200	200	50
Landings	229	163	31	225	151	208	187	11

[1] Interim TAC, landings to 20 November 2006.

Resource Assessment

Commercial catch rate has declined in this area since the high of 2003 and the 2006 estimate of 13 kg/h falls below the long-term median (14.5 kg/h, 1996-2005; Figure 19). Effort has continued to increase since 2002.

Commercial catch rates indicate that outside of St. Mary's Bay, there are two major areas of concentration: east of 66°22'W in the more inshore areas of Brier and Lurcher and west of 66°30'W mainly in the Lurcher area (south of 44°00'N). Catch rates have diminished in both areas since 2003. Catch rates were also lower throughout St. Mary's Bay in 2006 compared to 2005.

Annual research vessel surveys have been conducted in the Brier Island and Lurcher Shoal areas each August from 1991 to 2003. Surveys in SPAs 1 and 4 were re-scheduled to August in 2004 to avoid problems with lobster gear in June. As a result, the survey in SPA 3 has been conducted in June since 2004. Due to coverage and design, only the results from the 1996 to 2006 surveys are comparable. Surveys of St. Mary's Bay have been conducted since 1999 although no surveys were conducted in 2002 and 2003 due to limited research vessel time.

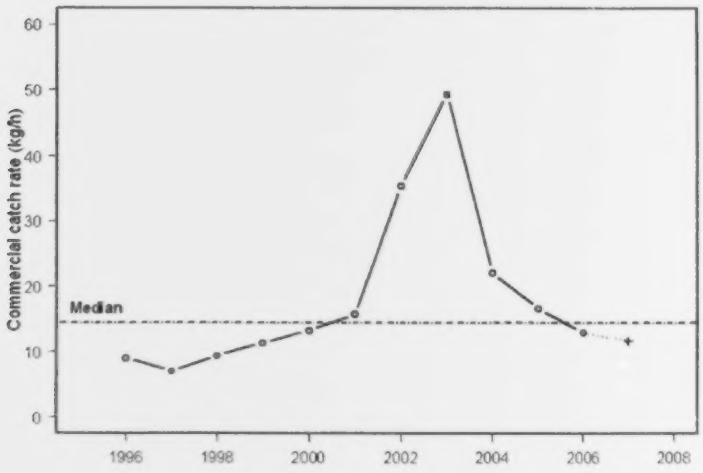


Figure 19. Commercial catch rate (kg/h) for scallops in SPA 3. Estimate for 2007 based on October 2006 catch rates only.

The spatial distributions of commercial size scallops from the survey are very similar to the pattern for commercial catch rate (Figure 20). However, the survey mean number per tow for 2006 declined from the 2005 estimates in Lurcher and St. Mary's Bay by 34% and 25%, respectively while remaining unchanged in the Brier area.

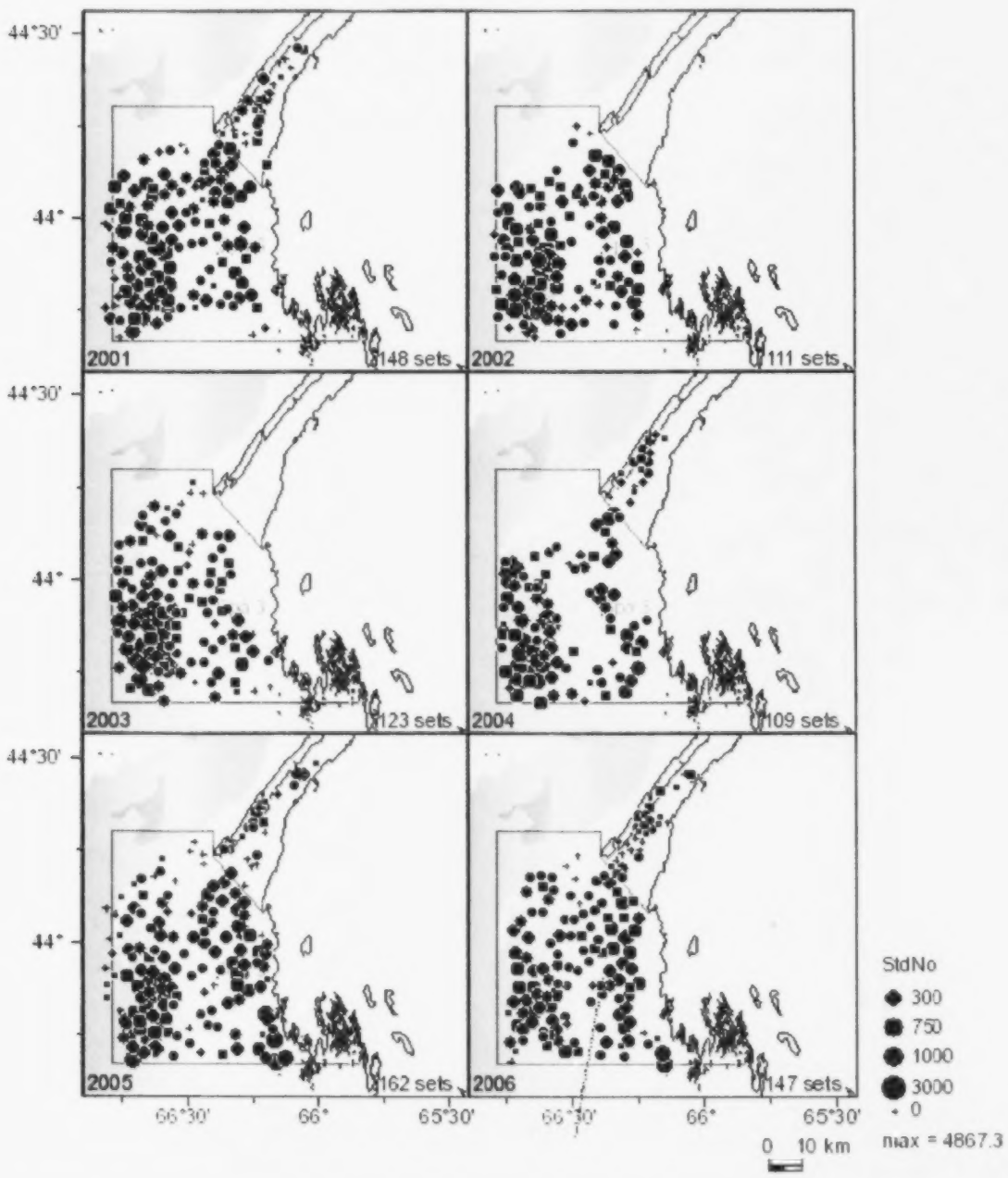


Figure 20. Spatial distribution of scallop catches from the 2001-2006 surveys of SPA 3 for commercial size (≥ 80 mm shell height) scallops. Surveys conducted in August until 2004 when the survey was changed to June.

Recruits exhibit very patchy distributions in this area with the largest concentrations being in the area west of 66°30'W (Figure 21). For the last four years, the number of tows with recruits has been low and these tows are mainly confined to the inshore areas. The last year-class of note was observed in 2004 (either 2003 or 2004 year-class) but this year-class was not observed again at larger sizes in subsequent surveys (Figure 22). The 2004 year-class looked strong in

St. Mary's Bay in 2005 but was not picked up in the 2006 survey (Figure 233). There appears to be little sign of recruitment for 2007.

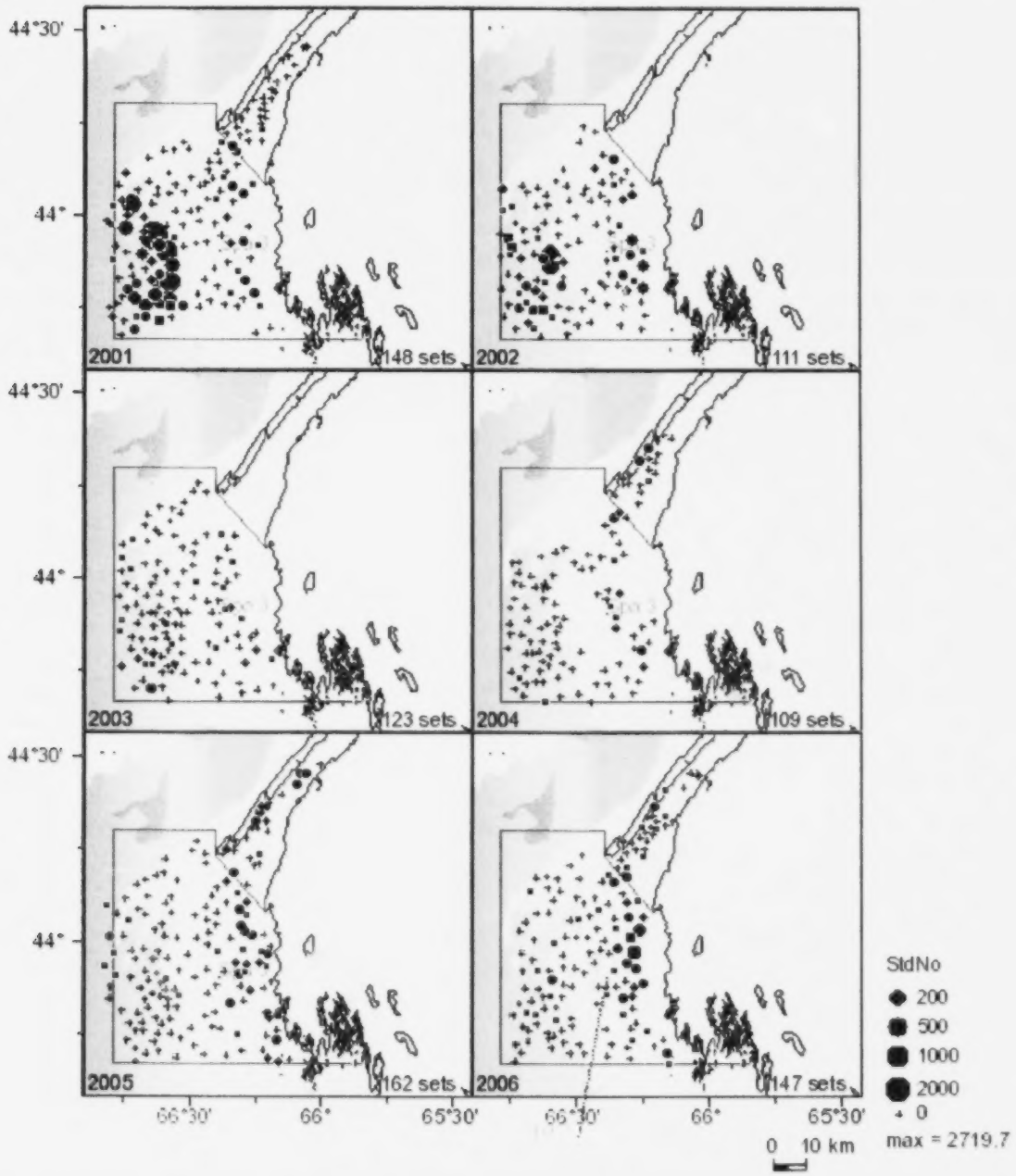


Figure 21. Spatial distribution of scallop catches from the 2001-2006 surveys of SPA 3 for recruit size (65-79 mm shell height) scallops. Surveys conducted in August until 2004 when the survey was changed to June.

The survey biomass index (kg/tow) indicates an increase in 2006 as the population is mainly made up of older scallops (Figure 24). However, variability was higher in 2006 reflecting the patchy spatial distribution of scallops in this area.

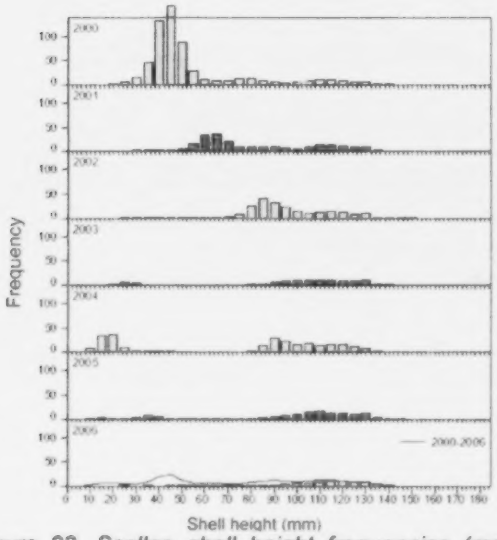


Figure 22. Scallop shell height frequencies (mean no./tow) from surveys of the Brier/Lurcher portion of SPA 3.

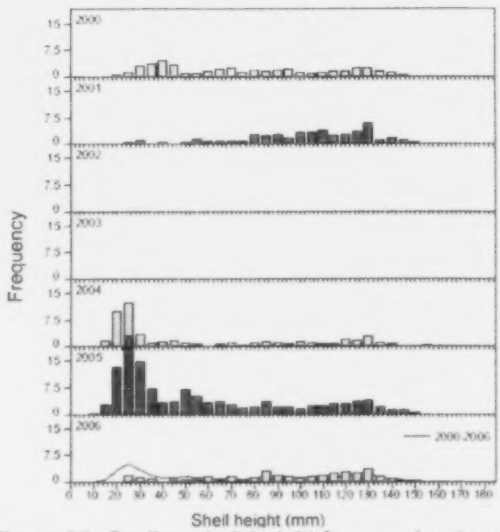


Figure 23. Scallop shell height frequencies (mean no./tow) from surveys of the St. Mary's Bay portion of SPA 3.

Past attempts to apply models to SPA 3 similar to those used in other areas have been unsuccessful. This year, a surplus production model was fit to catch and commercial catch rate data from 1996 to present to evaluate the impact of different catch levels in 2006/2007. The model fit the data well possibly due to the low variation in recruitment in the last few years and provided reasonable predictions for 2005 and 2006 (Figure 25).

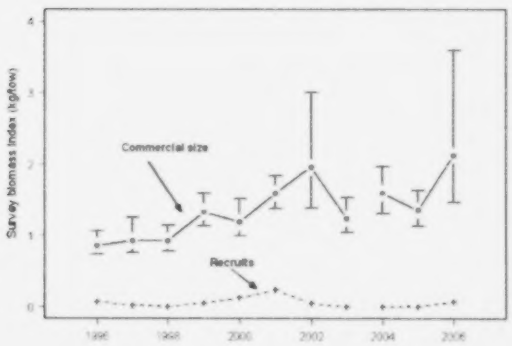


Figure 24. Survey biomass index (kg/tow) for commercial size (≥ 80 mm shell height) and recruit (65-79 mm shell height) scallops in the Brier/Lurcher portion of SPA 3. Commercial biomass index has 95% confidence intervals included. Surveys conducted in August until 2004 when the survey was changed to June.

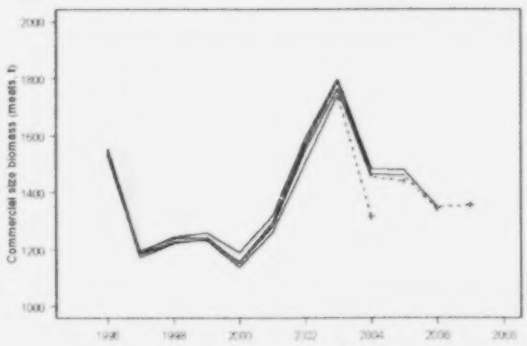


Figure 25. Comparison of biomass estimates and forecasts for a surplus production model fitted to commercial catch rate and landings data. Models are fit to data for 1996-2003, 1996-2004, 1996-2005, and 1996-2006 with forecasts to 2004, 2005, 2006, and 2007, respectively. Forecasts for first three models used actual landings while the model for 2006 used a catch of 200 t for 2006/2007.

Conclusions and Advice

There are no reference points for this fishery. A catch of 200 t in 2006/2007 is expected to result in a median exploitation rate of 0.20.

Catches in 2006/2007 (meats, t)	Median exploitation	$Pr(e_{2006}) \geq 0.2$
150	0.15	0.34
200	0.20	0.50
250	0.25	0.62

Overall, the advice is not much different then it has been for the last two years for this fishery. At current population levels, a catch of 200 t would likely result in little change in biomass and catches less than this should result in a small increase in biomass. A catch of 200 t should correspond to a commercial catch rate of around 15 to 16 kg/h.

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition, research and monitoring focussing on determining the conditions resulting in episodic die-offs is required.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruit and prerecruit scallops needs to be investigated.

SPA 4 – Digby

Fishery

Landings in SPA 4 steadily declined from 1991 to 1995 as the remnants of large year-classes (1984, 1985) were fished down (Figure 26). Portions of what is now SPA 4 were closed in 1995 and 1996 because of low stock levels. The increase in landings starting in 2001 was due to the strong 1998 year-class recruiting to the fishery. In October 2001, fishing was restricted to the Digby Gut up the Bay to Parkers Cove to protect the abundant 1998 year-class. As this year-class grew and recruited to the fishery, fishing occurred throughout SPA 4.

The 2005/2006 season extended from 1 October to 7 May and 133 t out of a TAC of 150 t was landed. An interim TAC of 100 t was set for the 2006/2007 season which opened 1 October 2006. As of the quota report of 20 November 2006, 23.2 t had been landed from SPA 4.

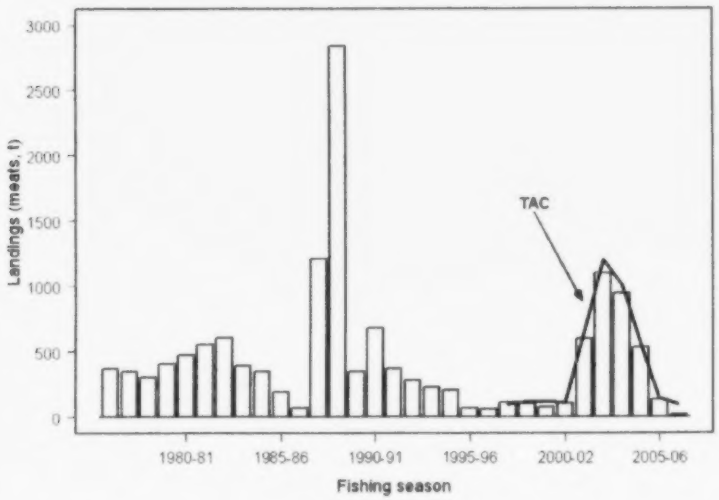


Figure 26. Scallop landings (meats, t) in SPA 4.

Landings (meats, t)

Season	Avg. 1997-00	2001/ 2002	2002/ 2003	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007[1]
TAC	112.5	650	1200	1000	550	150	100
Landings	92.5	598	1097	945	535	133	23

[1] Interim TAC, landings to 20 November 2006.

Resource Assessment

Commercial catch rates in 2005/2006 (11.4 kg/h) declined from the previous four years (Figure 27) and were below the median for the time-series (1976-2005) of 21.3 kg/h. Average catch rates from October 2006 (9.9 kg/h) are 18% lower than the average for the same time in 2005 (12.2 kg/h). Based upon recent trends of catch rates over the season, average catch rate over the entire 2006/2007 season is expected to be less than the October 2006 rate.

In general, the fishery is continuing to concentrate on older scallops as indicated by the large meat weights in 2004/05 and 2005/06 compared to 2003/04.

Research vessel surveys, using a consistent stratified random design, have been conducted since 1981. Up to 2003, the surveys have been conducted in June every year, but the expanding distribution of lobster traps in the area necessitated rescheduling the survey to August in 2004. However, survey vessel mechanical problems resulted in the 2004 survey being conducted in September. The 2005 and 2006 surveys of SPA 4 were completed in August as planned.

As in the previous two years, the higher densities of commercial size scallops tend to be found in the strata below the Digby Gut strata but these densities have declined from the previous year while the strata above Digby Gut have increased. Overall, the mean number per tow of commercial size scallops declined by 13% compared to the 2005 survey and by 34% in the deeper portions of the area (≥ 90 m).

The mean number per tow of recruits in 2006 is more than twice that for the previous year with the major portion of these recruits in the Digby Gut to Parker's Cove strata. However, this level of recruitment is within the range of the low recruitment characteristic of most years in the time series and much lower than that for the major recruitment levels in 1987, 1988 and 2001 (Figure 28).

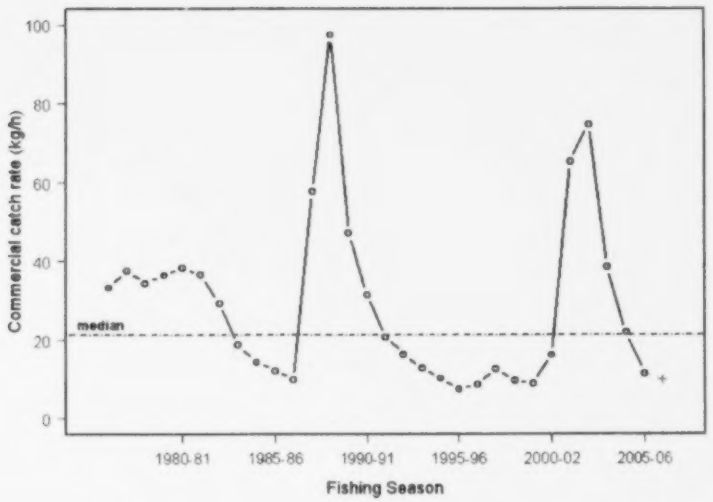


Figure 27. Commercial catch rate (kg/h) for scallops in SPA 4. Catch rate for 2006-2007 refers to October 2006 only.

Survey numbers indicate that the stronger than average 1998 year-class has been fished down (Figure 29). The 2006 survey did not pick up any significant signs of prerecruits in the area and there are no indications in the survey of any substantial recruitment for the next two to three years. However, one report from October indicated that a number of small scallops (<20 mm) were caught in the commercial fishery in the Gulliver's Head and Centreville area.

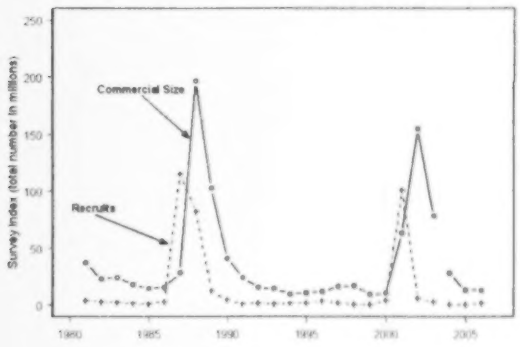


Figure 28. Survey abundance index (total numbers in millions) for commercial size (≥ 80 mm shell height) and recruit (65-79 mm shell height) scallops in SPA 4. The break in the survey series indicates the change in timing of the survey from June in 1981-2003 to August/September in 2004-2006.

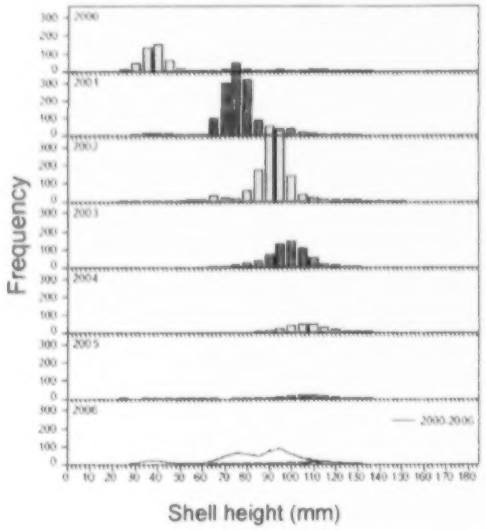


Figure 29. Scallop shell height frequencies (mean no./tow) from surveys of SPA 4. Surveys were conducted in June during 1981-2003 and in August/September during 2004-2006.

The survey biomass for commercial size scallops in 2006 indicated a 12% increase over 2005 (Figure 30) in contrast to the decline in numbers over the two years. This increase probably reflects the small increase in yield noted previously.

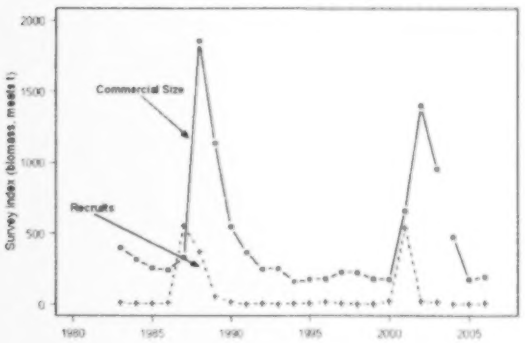


Figure 30. Trends in survey biomass estimates (meats, t) of commercial size (≥ 80 mm shell height) and recruit (65-79 mm shell height) scallops from SPA 4. Break indicates change from June to August surveys in 2004.

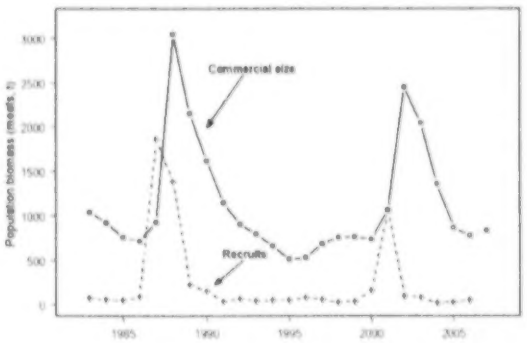


Figure 31. Trends in model biomass estimates (meats, t) of commercial size (≥ 80 mm shell height) and recruit (65-79 mm shell height) scallops in SPA 4. Forecast for 2007 based on a catch of 100 t in 2006-2007 fishing season.

As in previous years, a delay-difference model was used to model the dynamics of the SPA 4 scallop population. Commercial size biomass in 2006 has decreased slightly and recruitment continues to be low (Figure 31). The projection to 2007 based upon a catch of 100 t in 2006/2007 suggests a slight increase in population. The contradiction between the survey biomass trends to 2006 (Figure 30) and the model estimates is explained by the change in

relative efficiency between the lined and unlined survey gear. Reasons for this change may be due to changes in size composition of the population but understanding the actual mechanism for this change requires a more in-depth study of the selectivity of the survey gear.

The current year estimate for non-fishing mortality (11%) suggests a doubling over the estimate in 2005 but this estimate is still within the range observed since 1992.

Last year's prediction for this year's biomass overshot the current estimate but the difference is in the range of previous differences between predicted and the current year's estimate (Figure 32).

Conclusions and Advice

In the 2005 assessment, a fishing strategy of 150 t in 2005/2006 and in 2006/2007 was predicted to have a 0.50 probability of resulting in exploitation rates at or below 0.2 which could allow the population biomass to increase slightly. The predicted exploitation rate for a catch of 133 t in 2005/2006 was 0.17 based on last year's population model. This year's model estimates the 2005/2006 exploitation rate for catch of 133 t as 0.16.

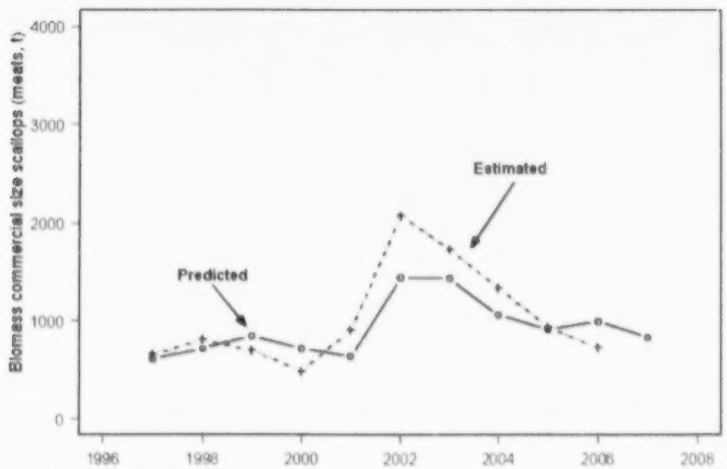


Figure 32. Comparison of predicted biomass from the previous year with the estimated biomass of commercial size (≥ 80 mm shell height) scallops in the current year for SPA 4. Prediction for 2007 made assuming a 2006/2007 catch of 100 t.

A catch of between 100 and 125 t in each of 2006/2007 and 2007/2008 would result in exploitation rates with a 50% or lower probability of exceeding 0.2.

		Catches in 2007/2008				
Catches in	Pr(e≥0.2)	Pr(e≥0.2) (exploitation)				
2006/07	(exploitation)	50 t	75 t	100 t	125 t	150 t
75 t	0.26 (0.12)	0.17 (0.08)	0.30 (0.12)	0.42 (0.16)	0.51 (0.21)	0.59 (0.25)
100 t	0.40 (0.17)	0.19 (0.09)	0.33 (0.13)	0.44 (0.17)	0.53 (0.22)	0.61 (0.26)
125 t	0.52 (0.21)	0.22 (0.09)	0.35 (0.14)	0.46 (0.18)	0.55 (0.23)	0.63 (0.27)

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition, research and monitoring focussing on determining the conditions resulting in episodic die-offs is required.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruit and prerecruit scallops needs to be investigated.

SPA 5 – Annapolis Basin

Fishery

The fishery in the Annapolis Basin (SPA 5) is only open to the Full Bay Fleet with the season running from 1 January to 31 March. In recent years, landings have varied between 2 and 20 t (Figure 33).

Landings dropped to 2.3 t in 2002 mainly due to increased effort directed towards SPA 4 in the winter. Increased landings in 2003 and 2004 were due to strong recruitment of 1999 and 2000 year-classes. Landings in 2006 were 6.1 t against a TAC of 15 t.

Landings (meats, t)

Season	Avg. 1997-00	2001	2002	2003	2004	2005	2006
TAC	11.8	10	10	10	25	10	15
Landings	11.2	8.9	2.3	12.2	20.4	13.3	6.1

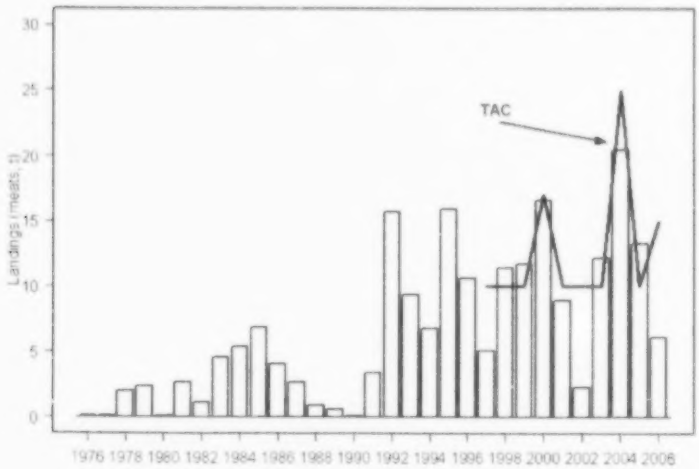


Figure 33. Scallop landings (meats, t) in SPA 5.

Resource Assessment

Commercial catch rate in 2006 (12.5 kg/h) was lower than the long term median at 21 kg/h (1977-2005; Figure 34) and approximately half of the catch rate reported in 2005. Effort declined from 2005 to 2006 by about 20%.

Research vessel surveys have been conducted on a regular basis in Annapolis Basin every June since 1997 in conjunction with the SPAs 1 and 4 surveys. The rescheduling of these surveys in 2004 to August and then to September resulted in the 2004 SPA 5 survey also being conducted in September. In 2005 and 2006, the SPA 5 surveys were completed in June.

The mean number per tow of commercial size scallops declined by 31% from 2005 to 2006 (Figure 35). Trends for recruits and prerecruits in 2006 were similar to those in 2005. Shell height frequencies indicate that the 2004 year-class dominates the prerecruit index (Figure 36). This year-class is much weaker than the 1999 and 2000 year-classes that contributed to the higher than average commercial size indices in 2002 and 2003, which in turn were reflected by the higher commercial catch rates in those same years (Figure 33).

Figure 34. Commercial catch rate (kg/h) for scallops in SPA 5.

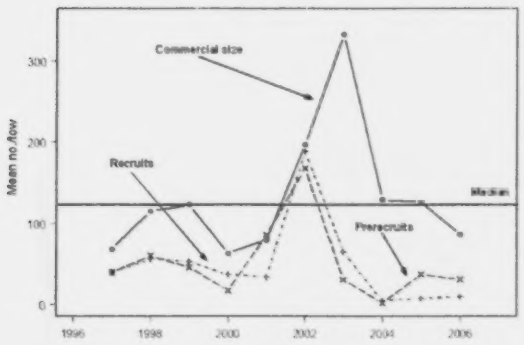


Figure 35. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height), recruit (65-79 mm shell height), and prerecruit (< 65 mm shell height) scallops in SPA 5. Median no./tow commercial size scallops calculated for years 1997 to 2005.

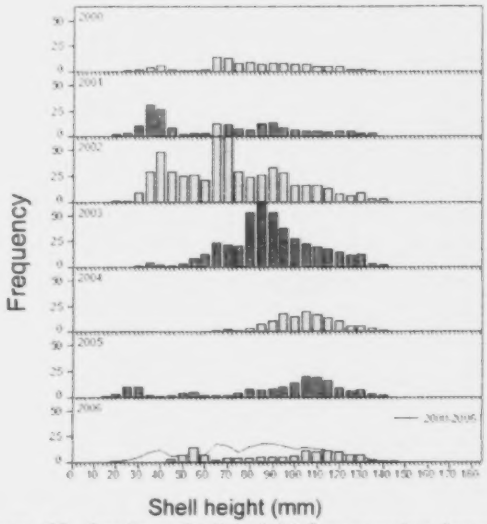


Figure 36. Scallop shell height frequencies (mean no./tow) from surveys of SPA 5.

Conclusions and Advice

A population model has yet to be developed for this SPA. Based on the survey, the abundance of commercial scallops declined in 2006. The commercial portion of the population is below the 1997-2005 median and little recruitment is expected for the next two years. Commercial catch rates also indicate a decline in the abundance of commercial size scallops. The TAC for 2007 should not exceed the average over the low abundance periods (1997-1999) of 10 t.

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition, research and monitoring focussing on determining the conditions resulting in episodic die-offs is required.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruit and prerecruit scallops needs to be investigated.

SPA 6 – Grand Manan and Southwest New Brunswick

Fishery

The areas around Grand Manan and off southwest New Brunswick are designated SPA 6. This area is further divided into SPAs 6A, 6B and 6C (see detailed map on last page, Figure 47).

Landings (meats, t)

Year	Avg. 1997-00	2001	2002	2003	2004	2005	2006
TAC	150	155	195	195	195	195	100
Landings	137	161	128	89	82	83	91[1]

[1] Landings to 10 November 2006.

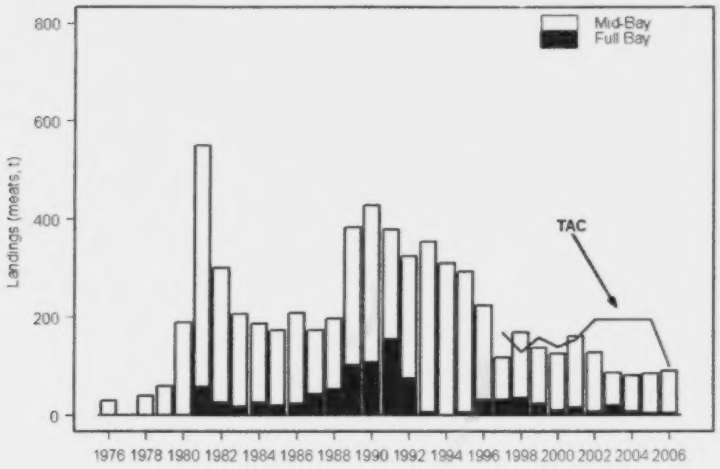


Figure 37. Scallop landings (meats, t) in SPA 6.

Landings to 10 November 2006 were 91 t against a TAC of 100 t. The 2006 SPA 6 quota for the Full Bay Fleet was 25 t and, unlike previous years, no arrangements were made for allocating this between the inside (SPAs 6B and 6C) and outside (6A) zones. Full Bay landings by area for 2006 were 0.9 t, 3.4 t and 0.3 t for SPAs 6 A, B and C respectively. This fleet has not caught its quota for the last five years as it has directed its effort to the other areas (Figure 37).

The 2006 quota for the Mid Bay Fleet was 75 t. The TAC was not split between the inside (SPAs 6B and 6C) and outside (6A) zones in 2006. Mid Bay landings for 2006 by area were 24.3 t, 41.8 t and 20.1 t for SPAs 6A, B and C respectively.

Resource Assessment

Effort for the Mid Bay Fleet has declined dramatically from 1993 and that of the Full Bay Fleet remains at low levels. The commercial catch rate for the Full Bay Fleet increased from 2000 to 2004 but given the low levels of effort, this index may not be tracking changes in the population (Figure 38). The Mid-Bay catch rate may be a better reflection of population trends as it is based on somewhat higher levels of effort. As it is, this index does not indicate any large changes in the last 10 years.

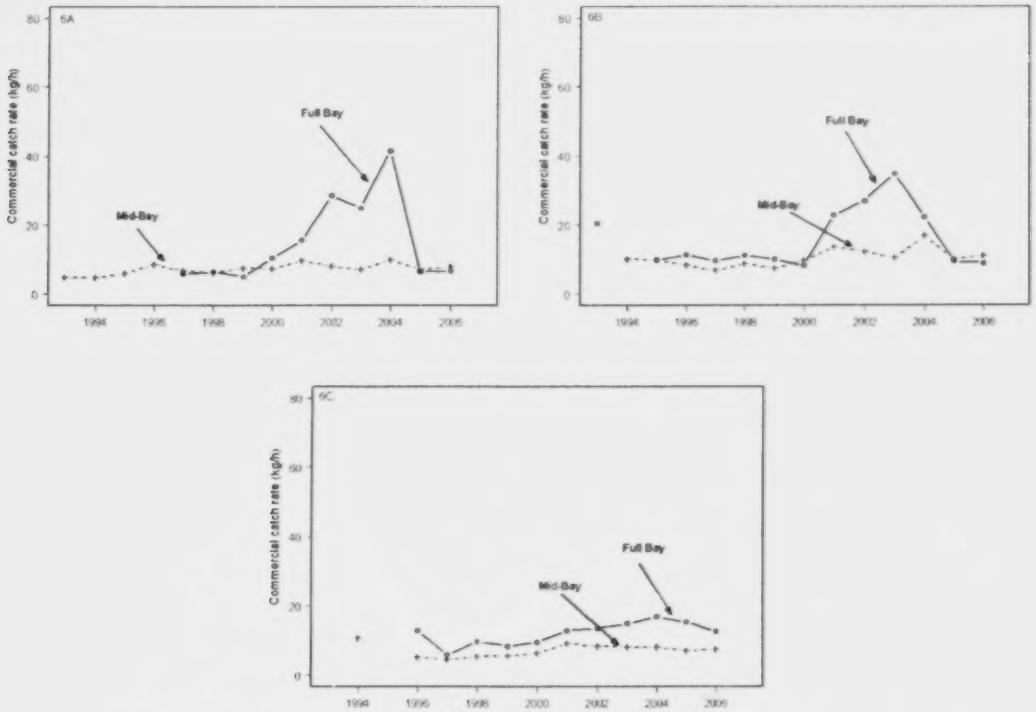


Figure 38. Commercial catch rate (kg/h) for scallops in SPAs 6A, 6B, and 6C.

Average meat weights sampled from the catch are consistent with fishing on an old population with little recruitment.

Research surveys in SPA 6 were initiated in 1979 but discontinued after 1991 until a new series was started in September 1997. This new series covered 6A and 6B and stations in 6C were included after 1999. In 2004, mechanical problems with the *CCGC J.L. Hart* resulted in cancelling the survey that year. The Bay of Fundy survey in 2005 was conducted on the *F/V Royal Fundy* and partial coverage of SPA 6 was completed. Only two random stations were made in 6A, 33 in 6B, and 7 in 6C. A number of exploratory stations were also made to learn more about the spatial distribution of the scallop beds.

The bathymetry of SPA 6 can be very rugged and a pure randomized survey design may not be the optimal survey method. In 2006, 180 stations were assigned to SPA 6 of which 16 were duplicates of 2005 tows in 6B. The locations of 30 tows were established based on historical sampling where scallop aggregations had been found. The remaining 144 stations were randomly selected throughout SPA 6. Unlike previous surveys in SPA 6, the 2006 survey using the *F/V Royal Fundy* was completed in July and to date provides the most extensive coverage of 6A, 6B and 6C (Figure 39). However, the sampling in 6C did not extend along the New Brunswick shore to Mace's Bay.

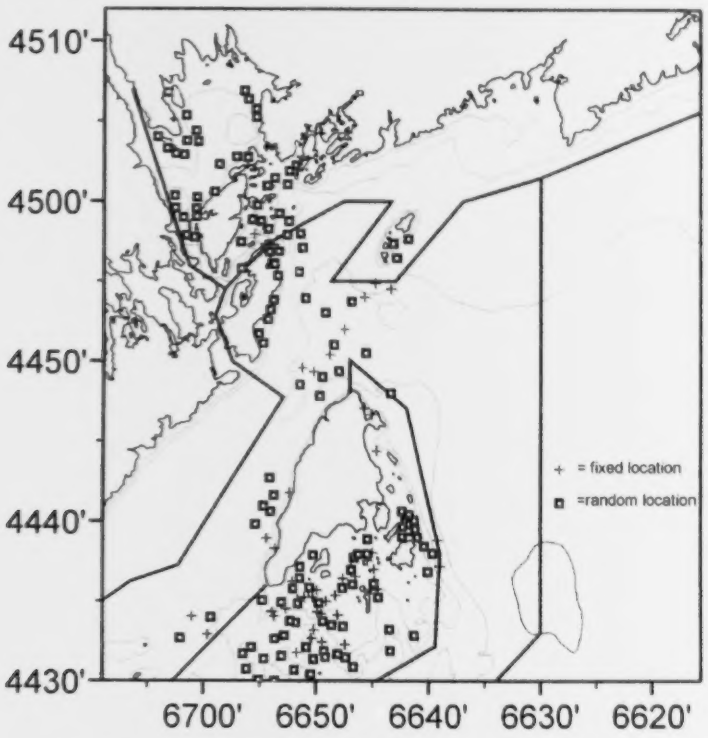


Figure 39. Location of random and fixed stations for the 2006 survey of SPA 6.

The survey showed high densities of small and commercial size scallops in localized areas (Figure 40). It should be noted however that the high densities of large animals north of Grand Manan had very low meat yield.

The shell height frequency for SPA 6A in 2006 shows that the commercial sizes have been fished down from 2003 (2005 only based on two tows) but there is evidence of higher than average recruitment (Figure 41). In 6B, the 2006 shell height frequency for commercial size animals was reduced from previous years and recruitment for the next two years appears to be at the lowest in the series (Figure 42). Relative to the other two areas, 6C has the lowest mean number per tow and little prospects for recruitment (Figure 43).

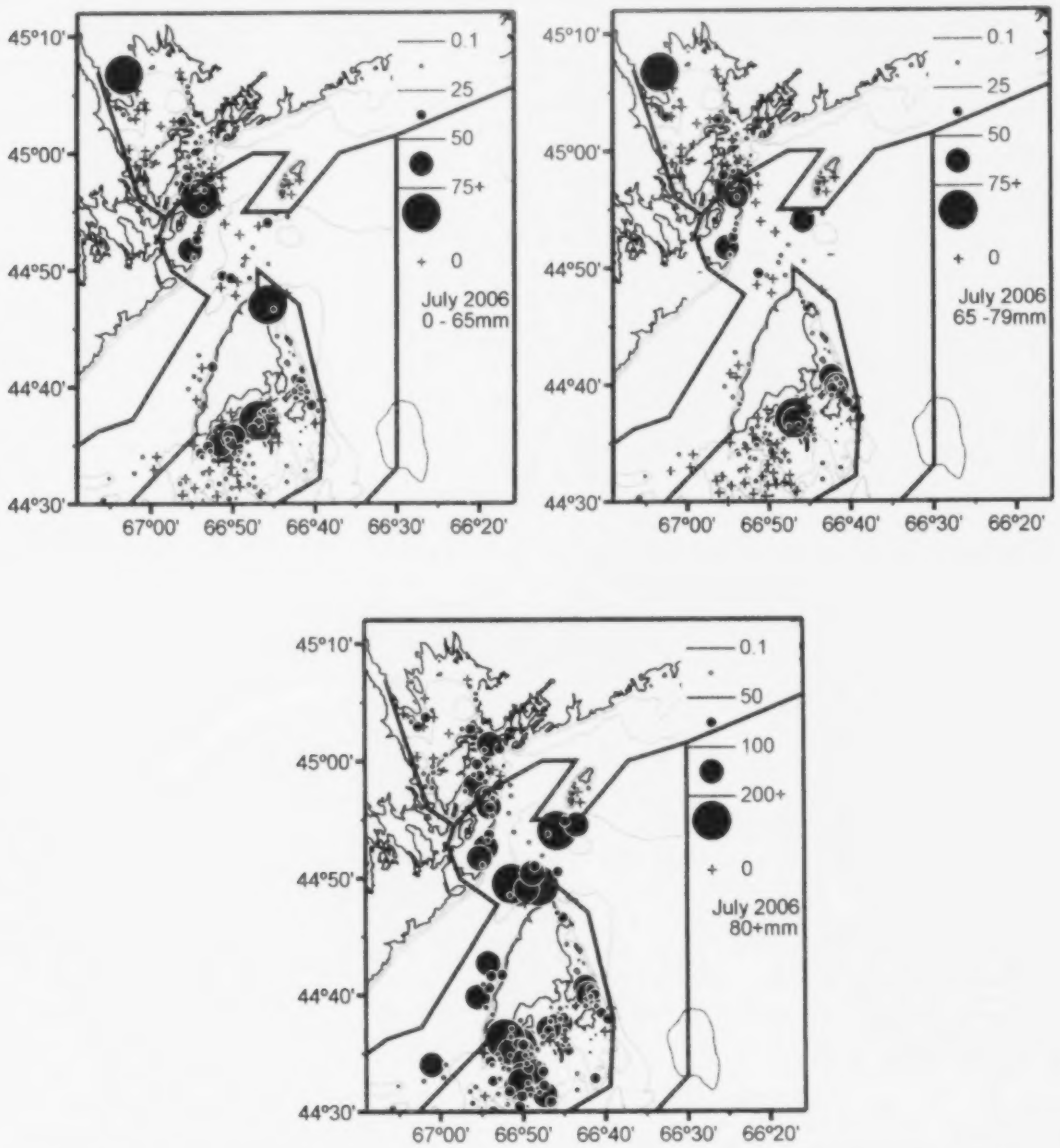


Figure 40. Spatial distribution of scallop catches from the 2006 survey of SPA 6. Top left panel: prerecruits (< 65 mm shell height); top right panel: recruits (65-79 mm shell height); bottom panel: commercial size (≥ 80 mm shell height).

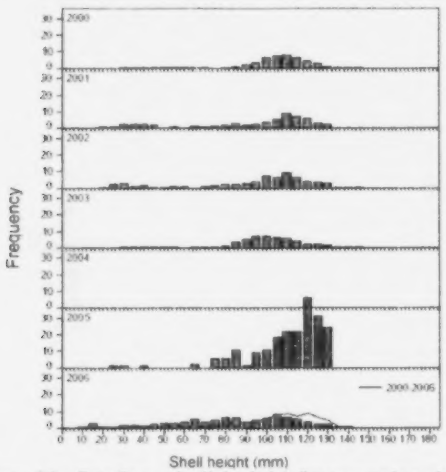


Figure 41. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6A. No survey was conducted in 2004 and the 2005 survey consisted of only 2 tows.

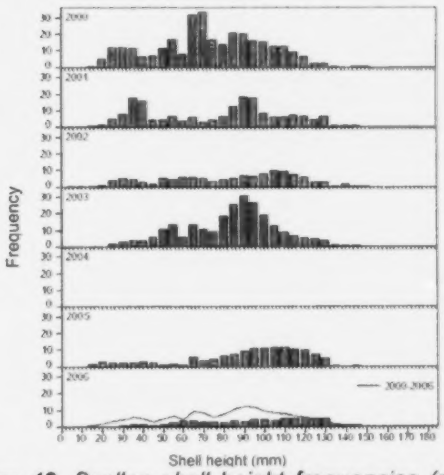


Figure 42. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6B. No survey was conducted in 2004.

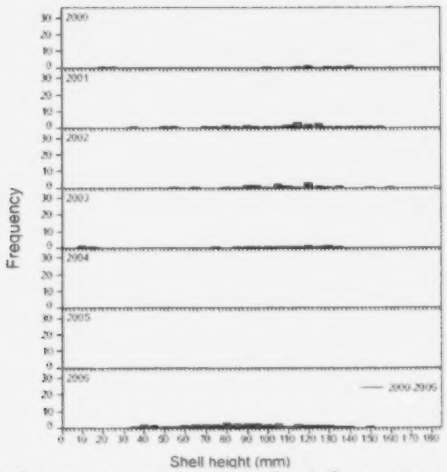


Figure 43. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6C. No survey was conducted in 2004 or 2005.

There has been little change in mean numbers per tow of commercial size scallops in 6A (Figure 44) but evidence of a decline in 6B since 2003 (Figure 45). The estimates for 6C may not be indicative of trends in this area due to the small sample sizes in the past and the incomplete coverage of the entire area (Figure 46).

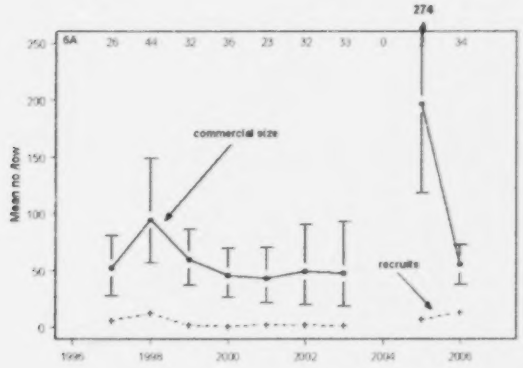


Figure 44. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height) and recruit (65-79 mm shell height) scallops in SPA 6A. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.

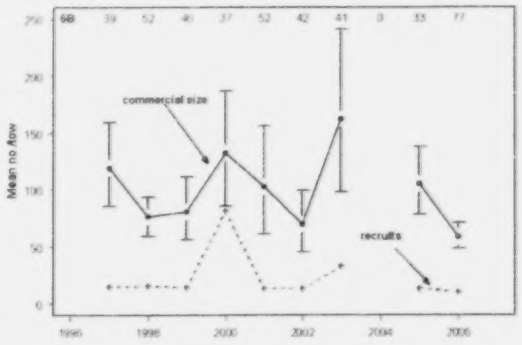


Figure 45. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height) and recruit (65-79 mm shell height) scallops in SPA 6B. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.

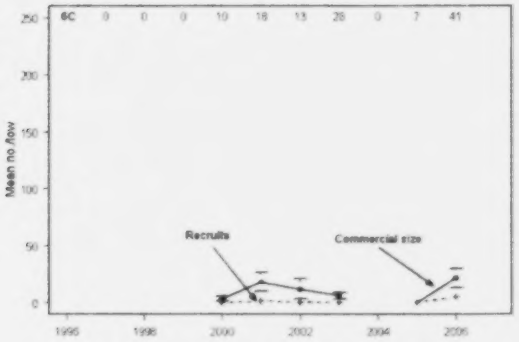


Figure 46. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height) and recruit (65-79 mm shell height) scallops in SPA 6C. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.

Conclusions and Advice

Evidence from the Mid-Bay commercial catch rates and the surveys suggest that the abundance of commercial size scallops remains unchanged from 2005 in SPAs 6A and 6C and possibly declining in SPA 6B. The survey suggests that this decline could be as much as 44-46%. Above average recruitment was only detected in SPA 6A.

There is no evidence to advise increasing the TAC above the current catches of 82-91 t.

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies

a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition, research and monitoring focussing on determining the conditions resulting in episodic die-offs is required.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruit and prerecruit scallops needs to be investigated.

Although improving, there are still problems with late submissions of monitoring documents.

SOURCES OF INFORMATION

DFO, 2004. Proceedings of the Maritimes Regional Advisory Process Stock Assessment Update of SPA 1,3,4,5 and 6 Scallop Stocks; 8-9 December 2004. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/049.

Smith, S.J., S. Rowe, and M.J. Lundy. 2007. Scallop Production Areas in the Bay of Fundy: Stock Status for 2006 and Forecast for 2007. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/005.

Smith, S.J, M.J. Lundy, D. Roddick, D. Pezzack, and C. Frail. 2003. Scallop Production Areas in the Bay of Fundy and Scallop Fishing Area 29: Stock Status and Forecast in 2002. DFO Can. Sci. Adv. Sec. Res. Doc. 2003/010.

FOR MORE INFORMATION

Contact: Stephen Smith, Mark Lundy, and Sherrylynn Rowe
Population Ecology Division
Department of Fisheries and Oceans
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth
Nova Scotia B2Y 4A2

Tel: (902) 426-3317 / 426-3733 / 426-8039
Fax: (902) 426-1862
E-Mail: smithsj@mar.dfo-mpo.gc.ca
lundym@mar.dfo-mpo.gc.ca
rowes@mar.dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice,
Maritimes Region and Gulf Region
Department of Fisheries and Oceans
P.O. Box 1006, Stn. B203
Dartmouth, Nova Scotia
Canada B2Y 4A2

Phone number: 902-426-7070
Fax: 902-426-5435
e-mail address: XMARMRAP@mar.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1480-4913 (Printed)
© Her Majesty the Queen in Right of Canada, 2007

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO, 2007. Stock Assessment Report on Scallops (*Placopecten magellanicus*) in Scallop Production Areas 1 to 6 in the Bay of Fundy. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/013.

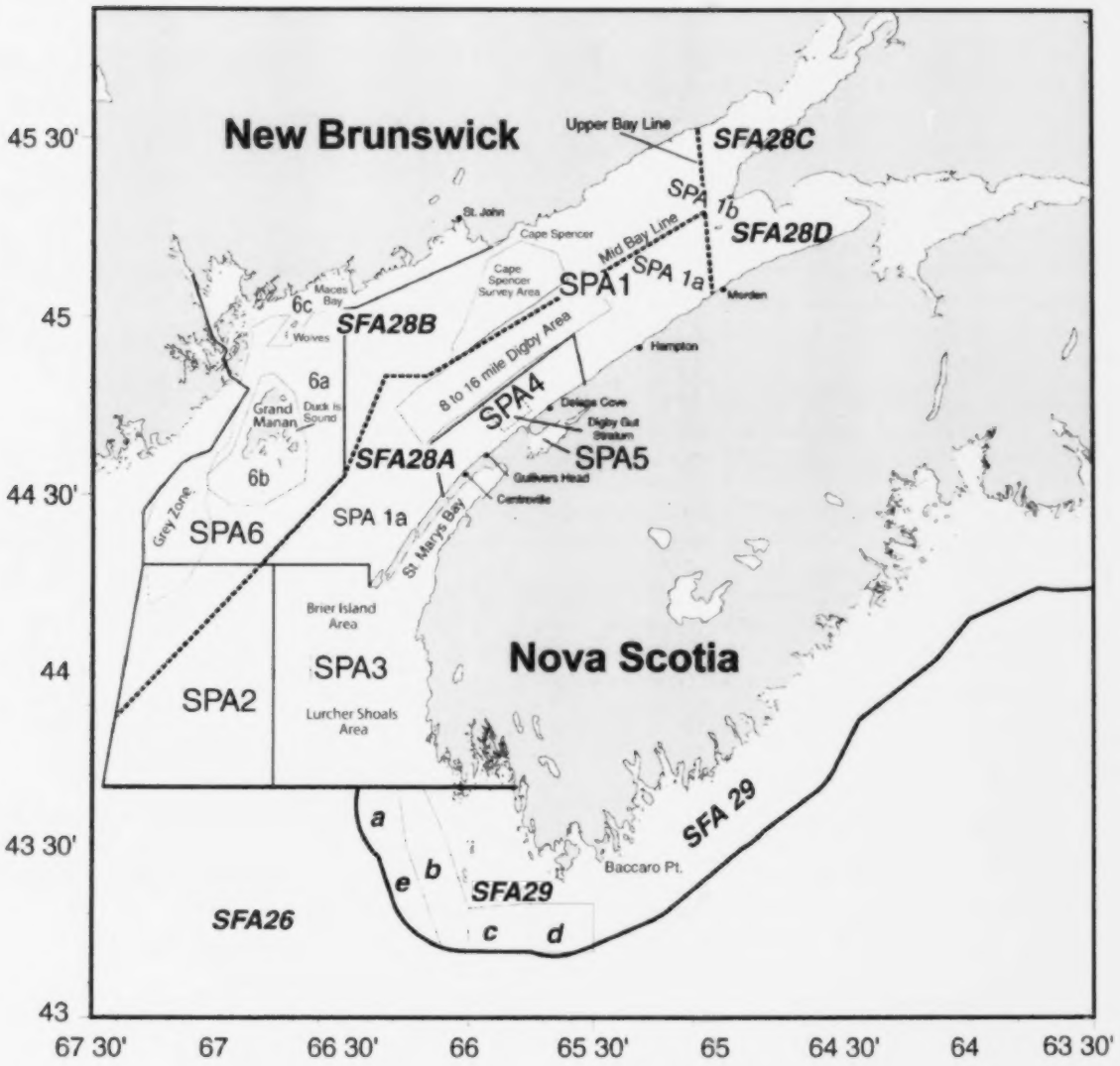


Figure 47. Locations and place names for inshore scallop grounds.